Assessing the Accuracy of Driver Passenger Counts: The Experience of AC Transit

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Passenger counts by bus drivers are subject to unknown errors. A sample of regular counts by AC Transit drivers, using electronic registering fareboxes, was compared to accurate counts taken by on-board checkers. Some of the counts read from the fareboxes are wildly inaccurate, probably for reasons other than driver error. If these are eliminated, the remaining counts average 94 percent of the true count. Patterns of error were found that suggest the possibility of developing correction formulas. Low driver counts correlate with high monthly pass usage, low use of cash fares in general, and high measured average cash fares.

The most obvious item of data needed to monitor transit service is a count of the patronage on each route. Yet obtaining accurate passenger counts remains a difficult problem for many properties. Methods used to count passengers include manual counts by drivers (every day or on selected days), counts by drivers aided by electronic fareboxes, special counts by checkers, estimation from loads observed from the street, counts by automatic passenger counters, and estimation from revenue based on average fares.

Many smaller operators, and some larger ones, are fortunate to have the cooperation of their drivers in routinely counting passengers on every run. In some cases this is done by operation of one or multiple counters (for various fare categories), with manual notation of the counter readings at specified times or locations. An example of a large operator that uses this method is the Port Authority of Allegheny County, in Pittsburgh, Pennsylvania. In other cases, including AC Transit, the process is more automated.

PROBLEMS WITH DRIVER PASSENGER COUNTS

Driver counts have the advantage of producing highly detailed data, and requiring no additional personnel. However, processing such large quantities of data may be time-consuming and expensive. Moreover, the counts may not be as accurate as those taken by personnel who are trained for the task and not distracted by other duties. Drivers, correctly no doubt, will tend to view passenger counting as less important than safe operation of the bus, collecting fares, and attending to passengers' questions and problems. In addition to human error, there are also potential problems with the electronic hardware and data collection system.

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SITUATION AT AC TRANSIT

In 1981–1982 AC Transit acquired electronic registering fareboxes, which are now installed on its entire fleet. The fareboxes automatically record revenue as it is deposited. In addition, they have a set of 10 push-button keys which the drivers activate to record passengers by fare category. At the end of each day, an electronic data probe is used to transfer the accumulated counts from each farebox onto a magnetic tape. The tape can be read by the District's mainframe computer to prepare farebox information reports.

The passenger count data from the fareboxes have not been used for official patronage reports due to concerns about their accuracy. Aside from driver errors, inaccuracies can result from farebox malfunction, loss of data when the fareboxes are probed, or failure to probe a bus. When a farebox is not probed, missing data for that day is easily detectable. A less detectable result is that the following day's count will be high because it includes the data for two days.

In 1985, staff of AC Transit's Department of Planning and Research, analyzed typical farebox data to determine the extent of these problems, and to recommend a procedure for overcoming them. They determined that about 25 percent of the farebox readings are either: (a) not matched to a bus number, (b) not distributed by fare type, or (c) unreasonably high or low. Unreasonably low counts produce an apparent average fare which is obviously higher than is reasonable. Unreasonably high counts are general obviously in error, with values in the thousands or tens of thousands. The current computer program for summarizing the counts, automatically flags and separates these erroneous readings.

The planning staff proposed a five-step process for producing monthly passenger count data from the farebox readings:

1. Choose a set of sample days each month for analysis. Days are chosen for which the reported coach count differs by no more than 5 percent from the scheduled number. This is intended to eliminate days with an excessive number of failed or missed probes. The proposal called for choosing 9 to 11 days each month (one school weekday per week, one school holiday weekday, two Saturdays, two Sundays, and all holidays).
2. Locate farebox readings which are either: (a) not matched to a bus number, (b) not distributed by fare type, (c) unreasonably high or low.
3. Replace these readings using appropriate averages, or estimates from revenue as available.

TABLE 1 AC TRANSIT RIDECHECK AND FAREBOX COUNTS

Route	Ridecheck Total	Bus Trips	Farebox Count	Monthly Passes	Transfers	Cash Fares	Youth Fares	Revenue
79	303	17	227	64	50	113	56	$100
90/92	184	missing	207	42	54	111	36	$71
72	464	5	441	81	104	256	71	$133
8	93	14	111	43	8	60	26	$29
66	143	11	130	33	43	54	20	$47
7	118	5	247	23	7	217	13	$37
40	326	4	279	85	53	141	37	$102
68	45	9	34	11	11	12	7	$10
78	297	9	296	14	95	187	139	$70
82	720	7	707	186	174	347	76	$217
46	154	28	46	3	3	40	29	$23
67	111	4	259	98	60	101	47	$64
80	163	11	170	41	27	102	42	$77
55	424	26	199	65	6	128	45	$102
56	212	9	180	94	30	56	22	$49
93	364	11	334	69	104	161	54	$121

4. Adjust for consistent undercounting by drivers by increasing the totals by 5 percent.

5. Factor up the total for each type of sample day to the total number of weekdays, Saturdays, Sundays and holidays in the month.

Most of this procedure could be automated, although staff would need to choose the sample days, and occasionally recalculate the average fare used to spot low counts in step 2. The staff proposal shows that, even though counts are taken every day, the quality of the resulting data is such that systemwide counts are only possible on a monthly average by day type. The system would be capable, however, of producing route-level counts daily, although some days would have missing data.

ACCURACY OF FAREBOX COUNTS

For this study AC Transit made 20 ridechecks that covered all activity by one bus for a full day. The farebox reports are also based on full-day bus runs. All the checks were on local service, within AC Transit's primary service area. Patterns of errors may be different among service types. In particular, it is likely that counts are more accurate on long express runs than on local runs with heavy boarding and alighting at many locations along the route. It had been hoped to conduct 20 ridechecks on each service type, including two types of express service, and low-density suburban service. Due to the difficulty of scheduling the checks, AC Transit chose to wait for analysis of the first set of checks before proceeding with the others.

Unfortunately, four of the 20 ridechecks could not be matched with corresponding farebox readings. In two cases, the corresponding readings were missing from the data file.

A summary of the ridecheck, and corresponding farebox data, is shown in Table 1. Figure 1 graphs the accuracy of the farebox counts, represented as the ratio of the farebox count to the ridecheck count. The ridecheck count is assumed to be correct. For 12 out of the 16 matched counts, the farebox count is between 75 percent and 119 percent of the ridecheck count. These may be considered "reasonable counts."

More farebox counts are low than high. This makes sense. In fact, it is hard to see how the drivers could produce a high count at all. The 12 "reasonable" farebox counts equal 94 percent of the corresponding ridecheck counts on average. The total of the farebox counts for the 12 routes is also 94 percent of the corresponding 12 ridecheck totals. In other words the farebox counts are low by 6 percent. This figure has a statistical margin of error of about 4 percent. Therefore, the 5 percent adjustment factor recommended by the Research and Planning Staff was a good conservative value.

For four of the 16 cases, the farebox count is high or low by at least a factor of two. In the case of the farebox counts which are high by a lot (Routes 7 and 67), the error is probably in the comparison process. For example, the farebox readings may include an unscheduled midday run, in addition to the morning and evening trippers that were ridechecked. The two extremely low farebox counts (Routes 46 and 55) appear to be due to transfers not having been counted at all. Both of these routes normally experience a high percentage of transfers, but the farebox readings show hardly any.

These analysis results support the recommendation of the Research and Planning staff. They show that, if obviously incorrect farebox readings are removed, the remaining data are accurate enough, on average, to provide a basis for systemwide patronage reporting.

PATTERNS OF ERROR

There are several factors which could be expected to produce errors of varying magnitude. Drivers are instructed to record a count for each boarding passenger. However, even in the case of cash-paying passengers, the driver does not have to enter a count in order for the farebox to accept the fares. A number of passengers paying discount fares could be recorded as a smaller number of full-fare passengers. Passengers paying to retain a transfer, and passengers paying a reduced fare along with a BART transfer, could be substantially under-

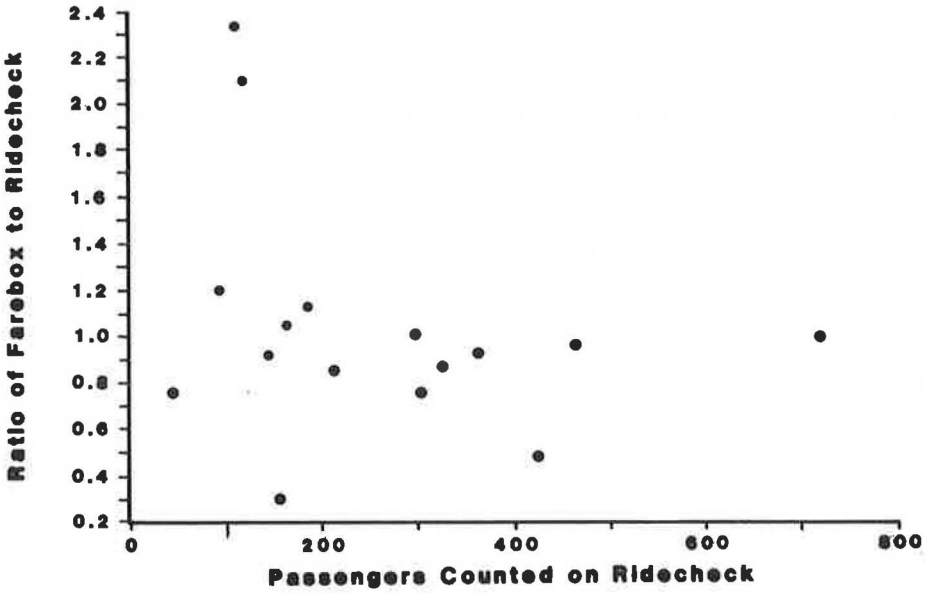

FIGURE 1 Passengers counted on ridecheck.

counted. (Transfers are free if the passenger surrenders the transfer slip, otherwise they cost 50 cents.) Both passengers paying with and surrendering a transfer, and passengers paying with a monthly pass are supposed to be recorded on the same farebox key. However, observations indicate that many passengers who do not pay a fare do not get recorded. The severity of undercounting due to any of these factors would be expected to be worse for high patronage levels than low patronage levels because large loads would create greater distraction from the counting task.

Figures 2 through 7 show plots comparing the extent of counting error (expressed as the ratio of the farebox count to the ridecheck count) to various factors which are suspected of contributing to undercounting. Only the 12 cases based on "reasonable" farebox counts are included. As this is a very small sample, all the conclusions here are very tentative. In considering the results, also recall that the reported distribution by fare category is probably in error, due to the influences just discussed. Some of the plots show definite patterns and some do not, as follows:

1. A low percentage paying cash fares of any type is associated with a lower farebox count. This is as expected.
2. A high percentage paying with a pass is associated with a lower farebox count. This is as expected.

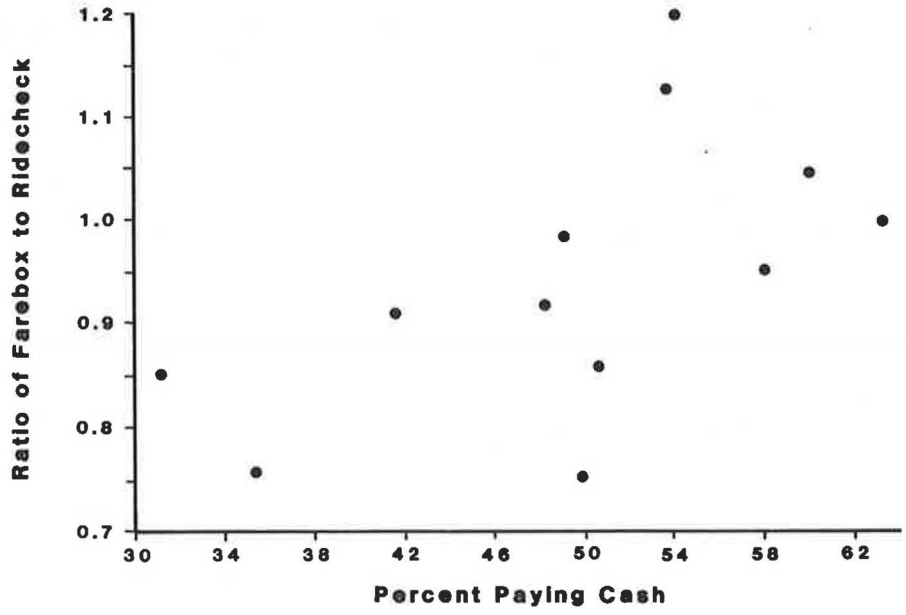

FIGURE 2 Percent paying cash.

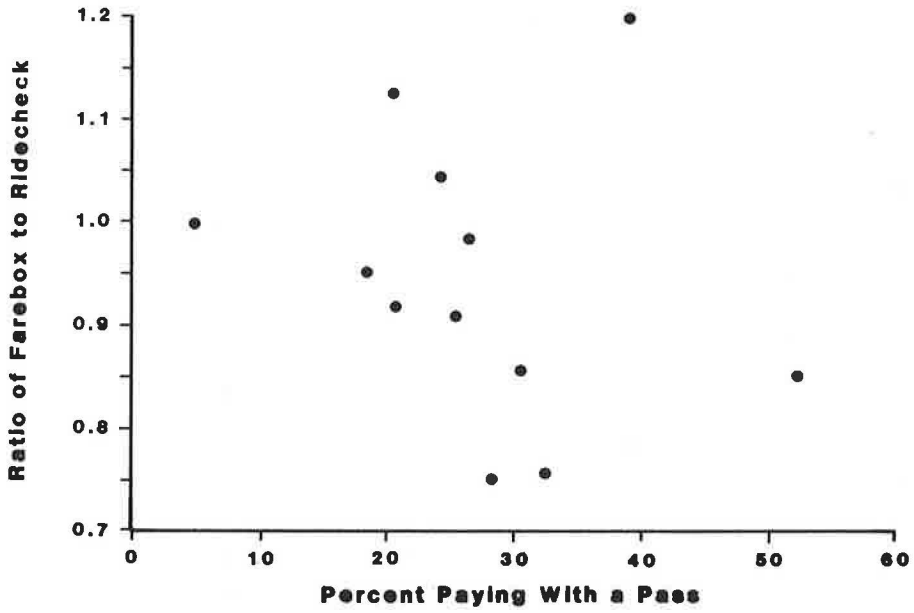

FIGURE 3 Percent paying with a pass.

3. The relationship with the percentage paying with a transfer is very weak.
4. There is no relationship with the percentage paying youth fare.
5. There is no relationship with total patronage.
6. There is a very strong relationship with average cash fare. A high average cash fare is associated with a lower count. On one level, this may be taken as a simple statement that an undercount necessarily produces a high estimate of average cash fare. In terms of the mechanism responsible, it may indicate that multiple discount fare patrons are being counted as a single full fare patron.

The strength of these relationships was tested by fitting regression lines to the data. The resulting equations might, in principle, provide the basis for correction formulas that would be an improvement on the simple 5 percent adjustment factor currently recommended. The results showed that the relationships with percent paying with a pass, and percent paying with a transfer are not statistically significant. Significant relationships (at the 95 percent confidence level) were found only with percent paying cash, and average cash fare. The estimated equations are:

$$\text{RATIO} = 1.3 - (0.54)\ (\text{Avg. Cash Fare})$$

$$R^2 = .45 \qquad t = -2.8$$

$$\text{RATIO} = 0.54 + (.008)\ (\text{Pct. Cash})$$

$$R^2 = .33 \qquad t = 2.3$$

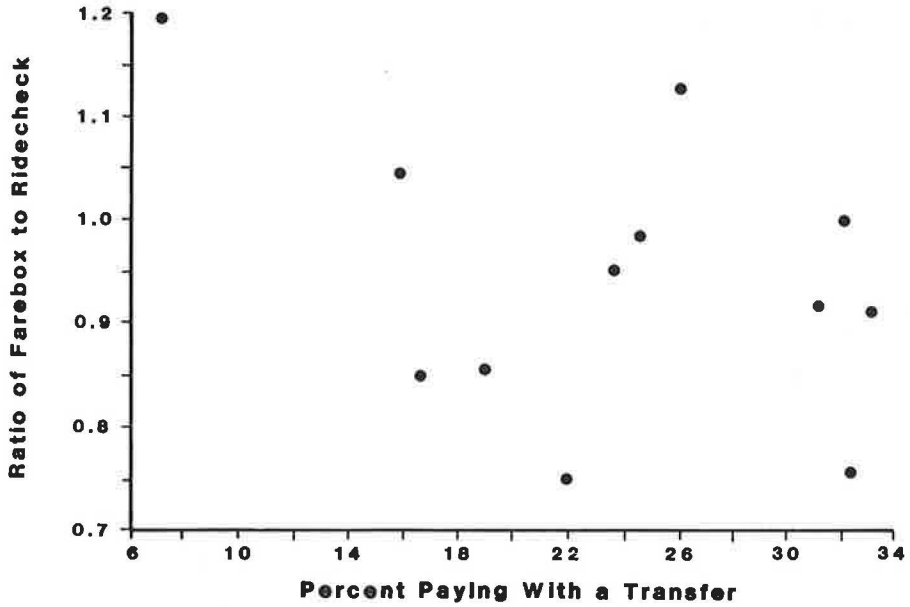

FIGURE 4 Percent paying with a transfer.

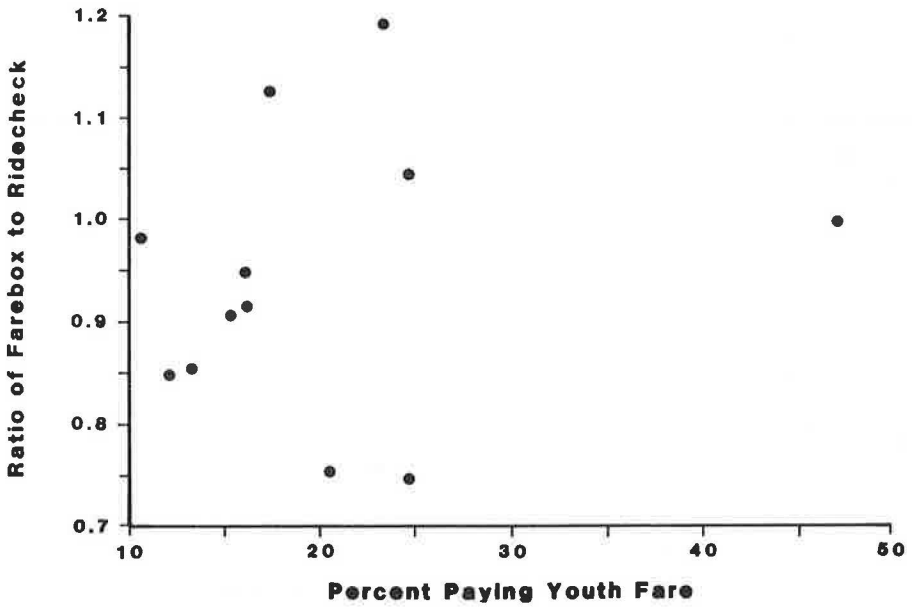

FIGURE 5 Percent paying youth fare.

Although percentage paying by pass, or with a transfer, had no significant relationship when tested alone, when combined they are both significant (at the 90 percent and 95 percent confidence levels respectively), with the following estimated equation:

$$\text{RATIO} = 1.45 - (.008) \times (\text{Pct. Pass}) \quad (t = -2.1) - (.013) \times (\text{Pct. Transfer}) \quad (t = -2.5)$$

$$R^2 = .44$$

However, much of the relationship with the percentage paying by transfer is due to one extreme observation (Route 8). When that observation is removed, the relationship with percent paying by transfer becomes not quite statistically significant. The relationship with percent paying by pass is unaffected.

This analysis shows that there are definite patterns to the errors in the farebox counts. However, more observations would be needed before any useful correction formulas could be estimated. All the observations analyzed were for urban local service. In all likelihood, different relationships apply for other service types.

PLANS FOR THE FUTURE

Initially, AC Transit plans to implement the original planning staff proposal. In addition, the District plans a two-pronged

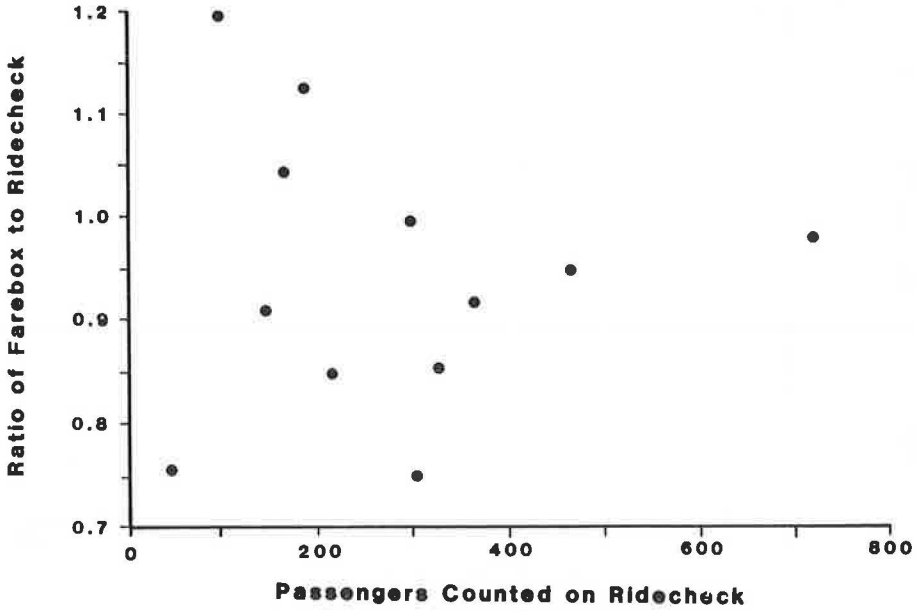

FIGURE 6 Passengers counted on ridecheck.

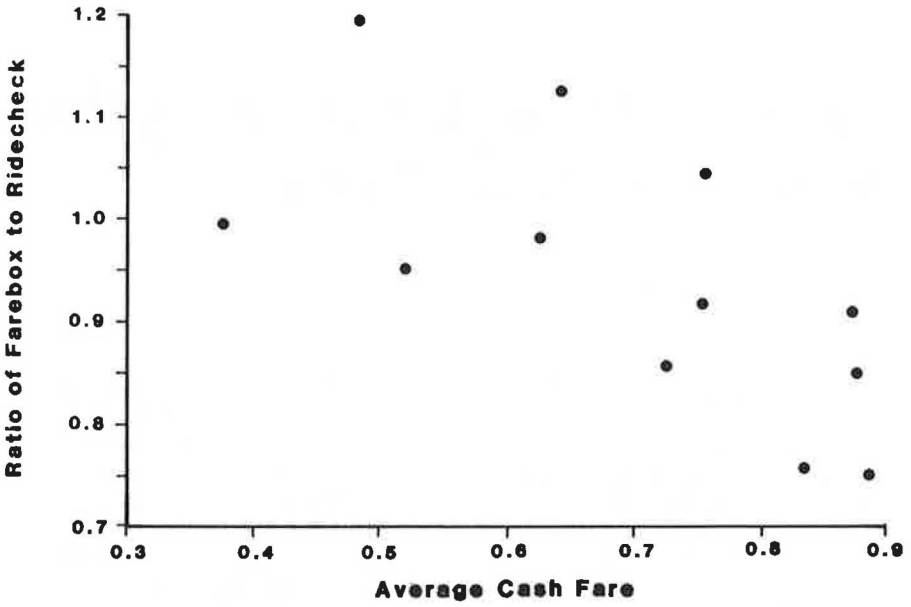

FIGURE 7 Average cash fare.

program to improve the accuracy and usefulness of the farebox patronage reporting system. The two parts are as follows:

1. Investigate the behavior of the drivers and the characteristics of the farebox counting system in more detail. This investigation would show which influences discourage the drivers from counting accurately. Besides providing a better basis for interpreting the data, and would provide a foundation for efforts to encourage more accurate counting.
2. Assemble a larger sample of matched farebox counts and accurate independent counts in order to estimate reliable correction formulas. An ideal system would combine use of fareboxes capable of trip-by-trip registration with regular Section 15 ridechecks.

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